Western Australian Viviparids (Prosobranchia:Mollusca)

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SUMMARY

The anatomy and distribution of the two species of viviparids occurring in Western Australia are consistent with the theory of a recent origin of Australian viviparids from S.E.Asia. Both species belong to the bellamyiniine genus *Notopala* Cotton. The evolution of these species reflects adaptation to permanent-water habitats in *N. essingtonensis* Frauenfeld and to seasonally dry habitats in *N. waterhousii* A. Adams and Angus.

INTRODUCTION

The S.E.Asian region is especially rich in viviparid species and genera (van Benthem Jutting, 1956; Brandt, 1974) and McMichael (1967) has postulated that the Australian viviparids originated from that area via the Indo-Malayan Archipelago. This theory is supported by the distribution of the family in Australia where it is wide-spread throughout the north of the continent but extends south only in the eastern states and there only as far south as the Murray River. In Western Australia such a southerly movement may have been impeded by the dry regions of the Pilbara, as viviparids are not recorded south of the Kimberley Region.

Where viviparids do occur their large size (relative to other freshwater gastropods) makes them a conspicuous part of the fauna and this has led to their inclusion in the collections of a number of early malacologists, most of whom produced new species names for their material (see later synonymies). Van Benthem Jutting (1956) and Brandt (1974) provide useful guides to the Indo-Malayan and S.E. Asian species but apart from Cotton (1935) almost no work has been published on the taxonomy or biology of the Australian species. Prashad (1928) does not deal with taxa below generic level and Iredale (1943) while providing syntheses of existing species presents little new information.

Pop	*Locality*	*Sample Size*	*Species*
1	The Grotto, Wyndham; Dec., 1977 WAM521-81	5	E
	May, 1978 WAM522-81	5	E
2	Bandicoot Bar, Ord River, Kununurra; WAM1-80	3	E
3	Lake Argyle, Kununurra; WAM488-79	4	E
4	Dunham River Gorge, Dunham River; WAM523-81	3	E
5	Cave Springs Rd, Kununurra; WAM526-81	5	W
6	Beta Creek, Wyndham-Kununurra Rd; WAM524-81	3	W
7	Dick Creek, Victoria Hwy Crossing; WAM527-81	1	W
8	Liveringa Pool, Fitzroy River; WAM489-79	3	W
9	Twelve Mile Lagoon, Parry Lagoons; WAM525-81	2	W

TABLE 1. Localities of the sample populations and their catalogue references at the Western Australian Museum. The species to which they were assigned are denoted 'E' for *N. essingtonensis* and 'W' for *N. waterhousii*. All sites were in the Kimberley Region of Western Australia.

In S.E.Asia certain species of viviparids act as intermediate hosts for echinostomes, intestinal flukes, and consumption of infected snails transmits the parasite to humans (Brandt, 1974). Although viviparids are not commonly consumed in Australia archeological evidence (Kendrick, 1973) suggests that they once formed part of the diet of Kimberley aboriginals. Johnson and Beckwith (1945, 1947) document the shedding of two species of trematode from *Notopala hanleyi* in South Australia, although neither species appears to be of medical or veterinary significance.

The confused state of viviparid taxonomy in Australia makes comparison of the Australian forms with other viviparids suspect. This work attempts to clarify the specific status of Western Australian viviparids while briefly discussing their generic and subfamilial affinities.

Methods and Materials

Total shell length and aperture length were measured for thirty-four specimens from nine localities (Table 1). Aperture length was measured as the distance from the insertion of the aperture to a point at 180° on the lip of the aperture. Only shells without substantial apex erosion were measured.

Snails were preserved for dissection in 10% buffered formalin for 24 hours and then transferred to 70% alcohol. Dissections were made for snails at localities 1 — 7, locality 1 being sampled in December, 1977 and May, 1978.

SYSTEMATICS

Family Viviparidae

Viviparid snails have medium sized, conical-turbinate, shells with a few rapidly increasing whorls. The periderm is brown to greenish-brown or yellow, often with darker spiral bands. The operculum is corneous and concentrically ringed.

The family is dioecious in the main with instances of parthenogenesis in species of the genus *Campeloma* (Mattox, 1937). Fertilization is internal, the developing embryos being retained in a modified pallial oviduct. Males are recognised by their swollen right tentacle, this being modified to act as a penis. Some sexual dimorphism of the shell is also reported. A more detailed account of viviparid reproductive anatomy may be found in Vail (1977).

The family is widespread, representatives occurring in the Paleartic, Neartic, Oriental, Ethiopian and Australian Regions (Prashad, 1982). Two genera, *Notopala* and *Centrapala* both Cotton, 1935, are recognised in Australia with a further genus, *Larina* A. Adams, 1855, doubtful (McMichael, 1967). Of these only *Notopala* is found in Western Australia. This genus is referable to the subfamily Bellamyinae.

Subfamily Bellamyinae Rohrbach, 1937

Erected primarily on anatomical grounds, the subfamily was proposed by Rohrbach (1937) to include those species having males with testis situated along the roof of the mantle cavity and not within the viscera and females with a long U-shaped seminal receptacle. The subfamily is further characterised by the possession of an unbanded protochonch (Wenz, 1938). The group is mainly composed of Ethiopian and Oriental species (Vail, 1977) with at least one genus, *Notopala*, present in Australia. The systematics of *Centrapala* and *Larina* are not within the scope of this paper.

Genus *Notopala* Cotton, 1935

Cotton erected the genus *Notopola*, with the type *Notopala hanleyi* Frauenfeld, 1964, to include the Australian viviparids exhibiting a fine spiral microsculpture of the shell. However, this microsculpture is by no means restricted to Australian species and similarities in anatomy and shell characters between species referred to *Notopala*, at least in Western Australian forms, and those referred to some S.E. Asian bellamyinine genera, such as *Filopaludina* Habe and *Idiopoma* Pilsbry, suggest the amalgamation of these genera. Before any generic revision could be undertaken a widely based study of the relevant species is needed.

Shells of *Notopala* are typical of the family. The convex whorls are sometimes angulate below the periphery and the aperture length is approximately half the total shell length. Embryonic shells are spirally sculptured but this is eroded with age and is not usually apparent in older animals. The apex is usually eroded in adults. No sexual dimorphism has been observed for shell characters.

The anatomies of both Western Australian species of *Notopala* examined correspond closely with those described in Vail (1977) for bellamyinine genera.

Members of the genus occur throughout northern Australia and also in central eastern Australia as far south as the Murray River. In Western Australia the two species recognised are restricted to the Kimberley Region.

The following synonymies were prepared from comparisons of specimens in the collection of the Western Australian Museum with type specimens from the British Museum of Natural History (marked * in these lists) and with drawings of types in Reeve (1863) and Smith (1882) and their synonomyies in Iredale (1943). The type of *Vivipara alisoni* from the Macleay Museum, Sydney, was also examined.

i) *Notopala essingtonensis* (Frauenfeld, 1862) fig 2a.
Type locality : Port Essington, Northern Australia.
1862 *Paludina essingtonensis* Frauenfeld, *Verh.zool-bot. Ges. Wien, 1862 : 1162.*

1863 * *Paludina ampullaroides* Reeve, *Conch. Icon.* 16, sp.1, pl.6, fig.30.
1663 *Paludina australis* Reeve, *Conch Icon.16,sp.71, pl.6.*
1865 * *Paludina affinis* Martens, *Ann.Mag.Nat.Hist.* ser. 3,16 :256.
1882 * *Vivipara trincta* Smith, *J.Linn.Soc.(Lond.)Zool. 16:265.*
1882 * *Vivipara dimidata* Smith, *J.Linn.Soc.(Lond.)Zool.* 16:265.

While the holotype of *P. essingtonensis* was unable to be located and the original

description did not include an illustration the name is applied to this species by virtue of its previous usage as a senior homonym of *P. ampullaroides*, *P. affinis* and *P. australis* (Iredale, 1943).

Characters of shell and anatomy are as for the genus. The aperture length is approximately two-thirds of the shell length in adults and the shell length:aperture length ratio increases more slowly with increasing shell length than in *N. waterhousii* (Fig. 1). The peristome is discontinuous with a thin parietal glaze and the shell is rarely umbilicate. The periderm is dark green to yellow-brown, often with a dark brown encrustation, and generally has three pronounced spiral colour bands above the periphery, often with one or two more obscure bands between them.

Embryonic development takes place in a hard translucent gel. Dissection of a single live animal suggests that the structure of this gel is un affected by fixing. Each embryo occupies a discrete section of the overall block. They are arranged in a developmental sequence with small eggs at the rear and miniature adults at the front. Each of the eight adult females examined from the Grotto contained an entire sequence in both May and December. Similar results were found at other *N. essingtonensis* populations.

Apical sculpture of the embryonic shells takes the form of two or three prominent raised spiral ridges. Periostracal hairs are few and reduced in form.

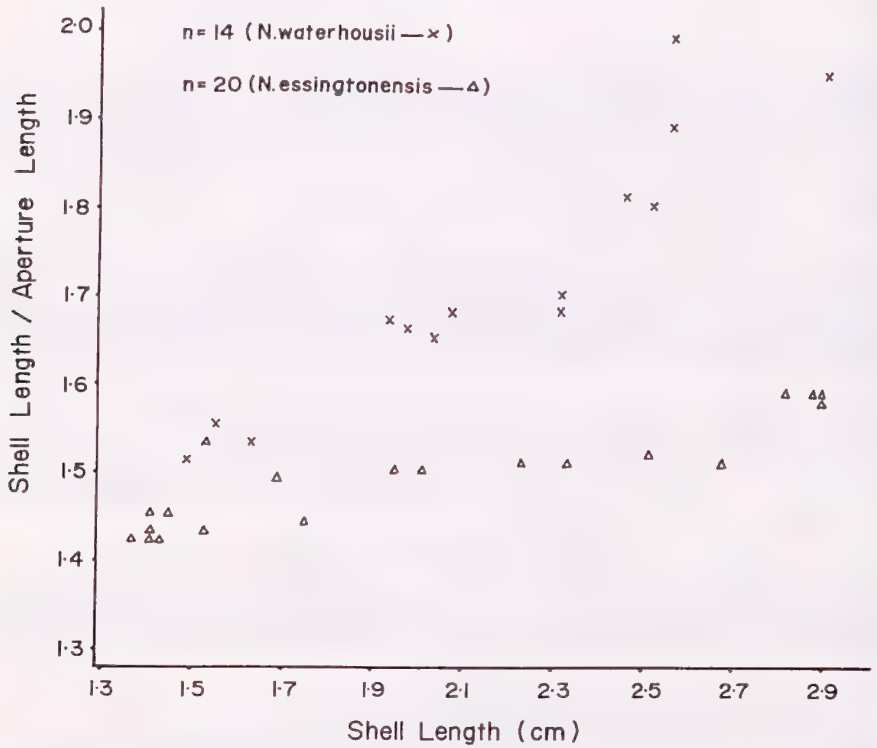

FIGURE 1 : Relationship of shell length to shell length/aperture length for *N. essingtonensis* and *N. waterhousii* (points designated e and w respectively). The equation of the regression line for *N. essingtonensis* is Y=0.09 X +1.31 ($r = 0.822$, $p < 0.001$, n=20); for *N. waterhousii* Y=0.25 X +1.16 ($r = 0.897$, $p < 0.001$, n=14), where Y is shell length/aperture length and X is shell length. Comparison of these lines using analysis of covariance reveals significantly different slopes ($F = 10.88$ 1,26 d.f. $p < 0.01$) but non-significantly different elevations.

The species occurs throughout the Kimberleys but is most prevalent in the northeast sector. It is also found in the Northern Territory and Queensland. Occurring primarily in large permanent waterbodies it is most frequently found on rocky substrates but may also be found on weeds and logs in rivers and large dams. In smaller waterbodies they are often confined to the underside of stones and observations of drying habitats suggest that they are not able to tolerate high temperatures.

ii) *Notopala waterhousii* (A. Adams and Angus, 1864) fig. 2, b.
Type locality : Newcastle Waters, Arnhem's Land, N. Australia.
1864 * *Vivipara waterhousii* A. Adams and Angus, *Proc.Zool.Soc.(Lond.)* 1836 : 414.

Figure 2. a) Shell of *N. essingtonensis* from the Lake Argyle population (WAM488-79).
b) Shell of *N. waterhousii* from Liveringa Pool population (WAM489-79).

1864 * *Vivipara kingi* A. Adams and Angus, *Proc.Zool.Soc.(Lond.)* 1863 : 415.
1879 *Vivipara alisoni* Brazier, *Proc.Linn.Soc.N.S.W.* 3 : 221.

Shell and anatomical characters as for the genus. Aperture length is approximately half the shell length in adults and is less than in individuals of *N. essingtonensis* of comparable length (Fig.1). The peristome is more or less continuous and the shell is often umbilicate. The aperture tends to be more rounded than in the former species. The periderm varies from greenish-brown to a pale straw colour and although banding patterns are similar to *N. essingtonensis* they are often fainter and sometimes absent.

Embryos develop in a fluid matrix in the pallial oviduct and members of a brood are of a similar size. The sculpture of these embryonic shells consists of a number of well developed periostracal hairs.

This species occurs throughout northern Australia and is widespread in the Kimberleys. Essentially an inhabitant of temporary swamps, these snails are most frequently associated with muddy substrates which crack deeply on drying.

DISCUSSION

The similarity of both shell and anatomy between the two species of *Notopala* examined and van Benthem Jutting (1956) and Brandt's (1974) descriptions of certain S.E. Asian bellamyinine genera supports McMichael's (1967) contention that the Australian viviparid fauna has had a relatively recent origin from S.E. Asia via the Indo-Malayan Archipelago. Iredale's (1943) separation of Prashad's (1928) "Vivipara Ampullaroides Group" from *Notopala* s.str. to form the subgenus *Notopalena* seems to represent overnaming in light of the similarities between the two species discussed in this paper, members of this subgenus and the species referred to *Notopala* s.str..

Banding patterns and some other shell characteristics are particularly variable between populations of *N. essingtonensis*, more so than for *N. waterhousii*, and further division of this species may be warranted. However, while the data gathered thus far consistently separate the two species discussed they are insufficient for a breakdown of *N. essingtonensis*.

The evolution of the physiological and morphological characters of *N. essingtonensis* and *N. waterhousii* appears to reflect adaptation to different habitats. The latter species being adapted to seasonally drying habitats while the former lives in permanently wet situations. Females of *N. waterhousii* seem to produce batches of young, presumably during favourable conditions although it is not known if this is seasonal or merely opportunistic, whereas *N. essingtonensis* females appear to produce young continuously, at least in the two seasons sampled.

Individuals of both species live for a number of years. Thus *N. waterhousii* must be able to withstand desiccation during periods when its habitat has dried. The aperture is smaller and rounder in this species and may be easier to seal with the operculum than in *N. essingtonensis* where visual inspection suggests that the aperture is unable to be sealed.

Although this paper has limited value above species level its synthesis with later works may prove useful in an evaluation of the status of *Notopala* in Australia and its relationship with the S.E. Asian forms.

ACKNOWLEDGEMENTS

This research was supported by a grant from the W.A. Dept of Public Health to Dr B.R. Wilson of the Western Australian Museum. I would also like to thank; Dr Wilson, for considerable encouragement; Mr G.W. Kendrick, for advice on shell characters; Dr D.H. Edward, for reading the manuscript. The British Museum of Natural History generously loaned their types of Australian viviparids and the Macleay Museum, through Dr W. F. Ponder of the Australian Museum, loaned the type of *Vivipara alisoni*. I also thank two anonymous reviewers. Mr Stan Hopwood produced the pictures for Fig. 2.

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